

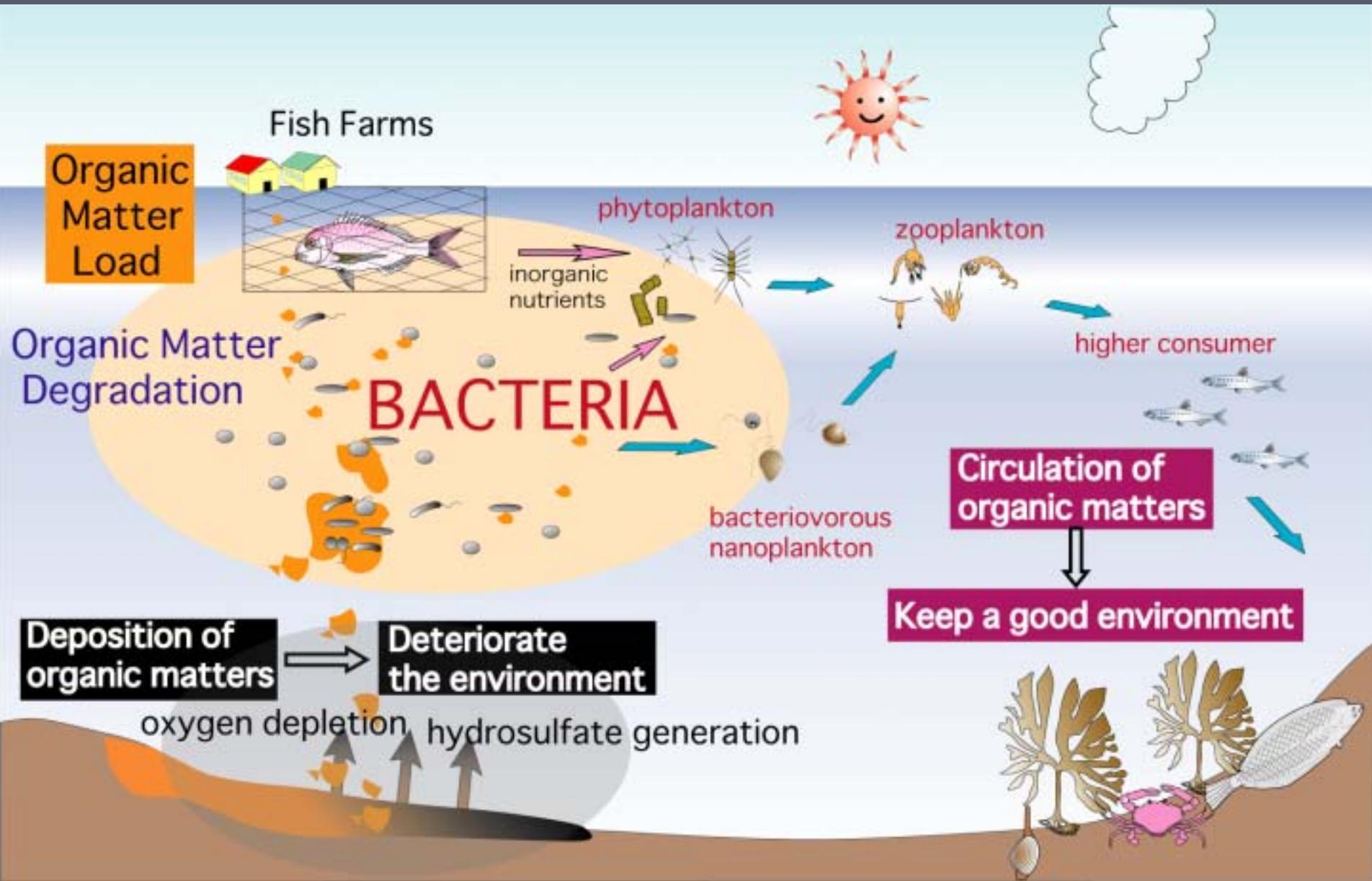
Microbial Activity and Community Structure in a Net-pen Aquaculture Area

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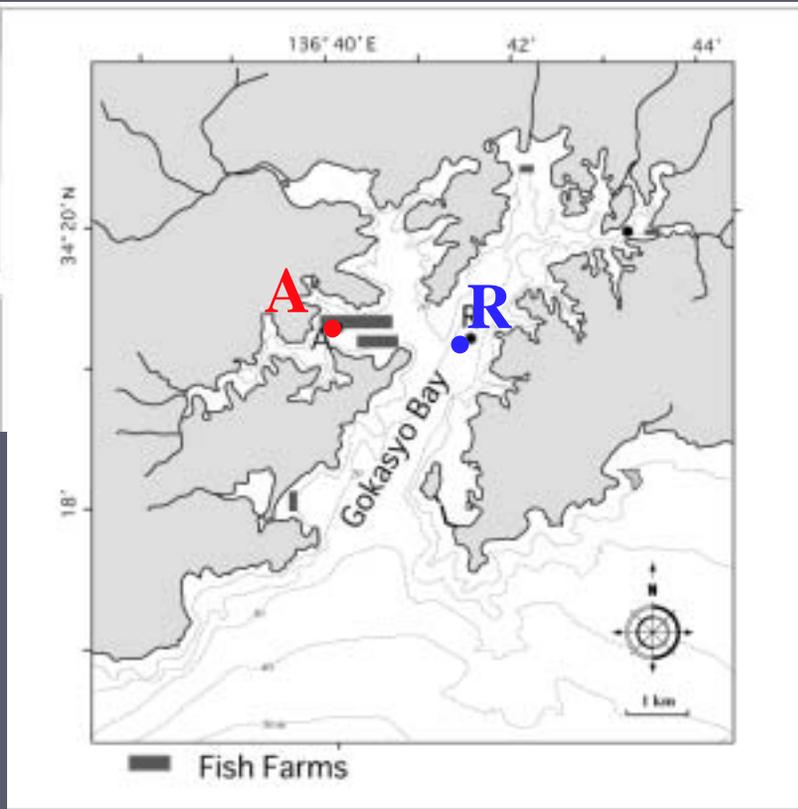
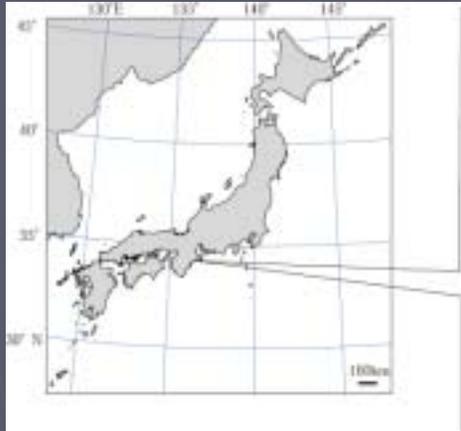
Organic matter cycling in an aquaculture area



The object of this study is to elucidate how microbial communities are affected by aquaculture

Microbial parameters examined

- ◆ Abundance and production rate
- ◆ Organic matter degrading activity
- ◆ Community structure

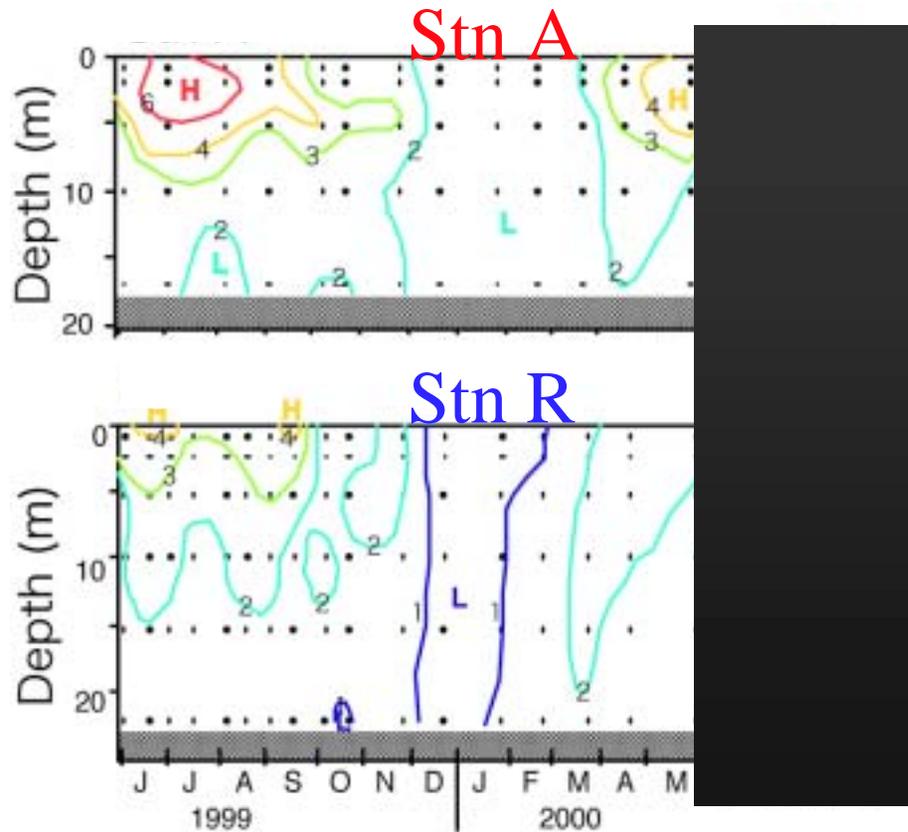


Study Site

Aquaculture
area; **Stn A**
Reference
area; **Stn R**

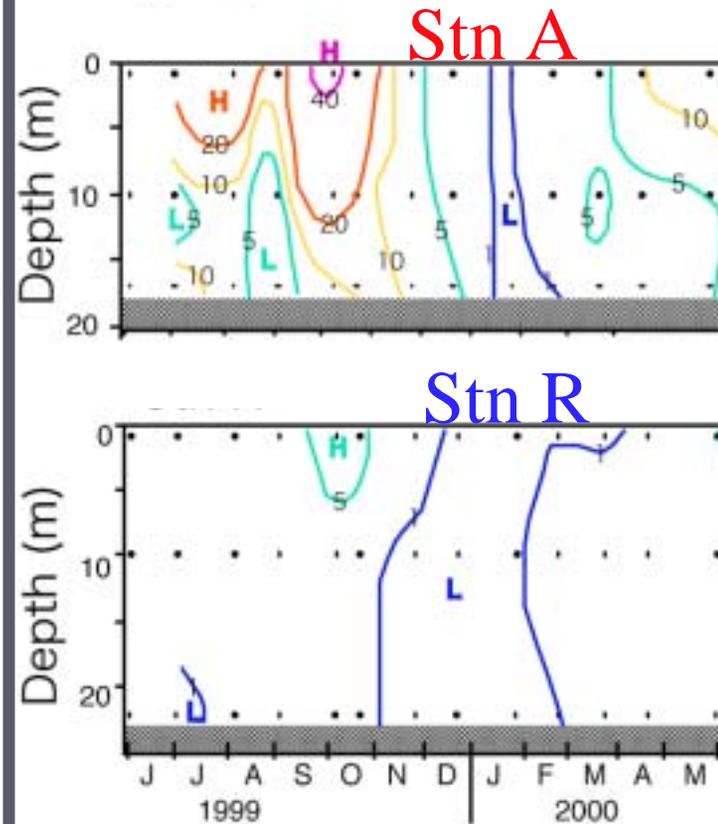
	Stn A		Stn R		P
	mean	range	mean	range	
Dissolved Organic Carbon (μM)	85	(51 - 161)	76	(51 - 116)	0.0002
Dissolved Organic Nitrogen (μM)	8.6	(3.9 - 23)	7.8	(4.7 - 10)	0.0245
Particulate Organic Carbon (μM)	8	(7.5 - 117)	7.8	(6.3 - 101)	0.907
Particulate Organic Nitrogen (μM)	1.1	(0.86 - 17.6)	1	(0.7 - 14.3)	0.361
Chlorophyll a ($\mu\text{g L}^{-1}$)	4.7	(0.2 - 45)	3.7	(0.1 - 26)	0.09

Abundance



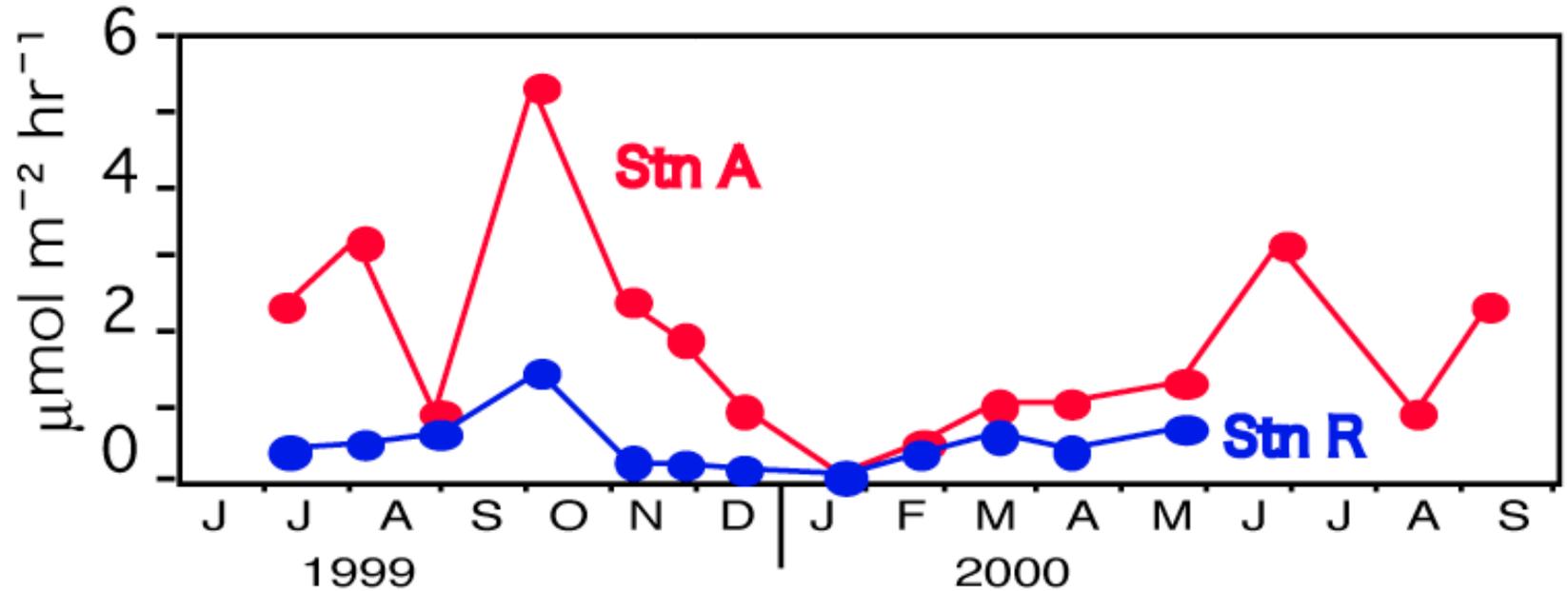
Mean Stn A; 2.4
Stn R; 1.8
($\times 10^9$ cells L^{-1})

Production rate



Mean Stn A; 85
Stn R; 23
($\text{pmol TdR } L^{-1} \text{ h}^{-1}$)

Bacterial production per unit area



$$\text{Stn A} / \text{Stn R} = 3.5$$

Correlation coefficients between bacterial and environmental parameters ($p < 0.05$)

Stn A	DOC	DON	POC	PON	Chla	Temp	Sal
Bacterial Abundance	0.56	0.56	0.77	0.73	0.57	0.61	-0.48
Bacterial Production	0.44		0.55	0.53	0.40	0.46	-0.77

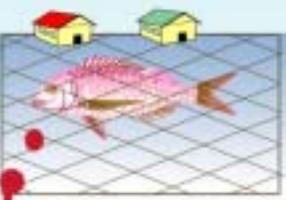
Stn R	DOC	DON	POC	PON	Chla	Temp	Sal
Bacterial Abundance	0.59	0.42				0.44	
Bacterial Production	0.36	0.40	0.46	0.50	0.46	0.37	



Input of organic matter from the fish farms to the surrounding waters might promote microbial activity

Fish food; 1500 t C y⁻¹
Fish farming area; 2 km²
Loss to dissolved fraction
; 60 %

Fish Farms



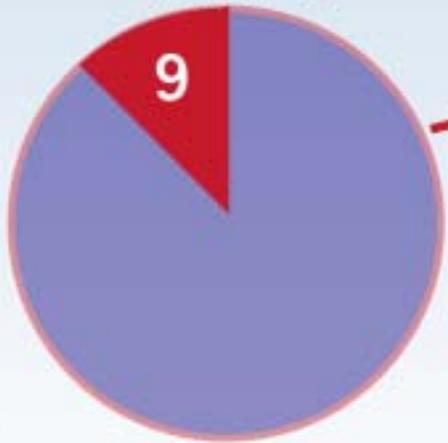
Aquaculture area
Stn A

Reference area
Stn R

Organic matter load
into seawater **37** μmol C m⁻² y⁻¹

Particulate
Stn A **8.0** μM C
Stn R **7.8**

Dissolved
Stn A **85** μM C
Stn R **76**



Organic matter
concentration in seawater

Bacterial
Production



StnA **6.8** μmol C L⁻¹ day⁻¹
StnR **1.8**

Bacterial abundance



StnA **4** μM C
StnR **3**

Bacterial secondary production
36 μmol C m⁻² y⁻¹

Microbial organic matter degradation

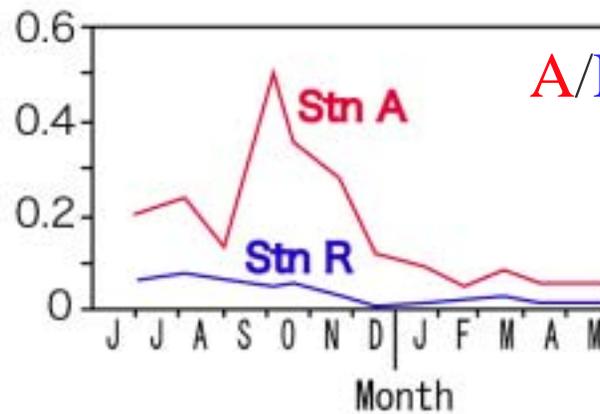
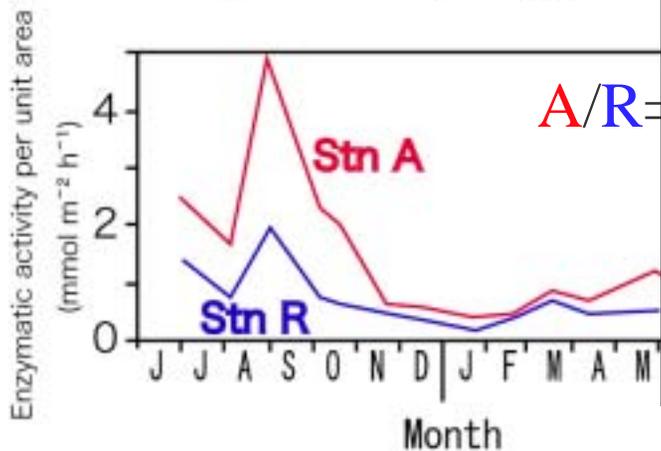
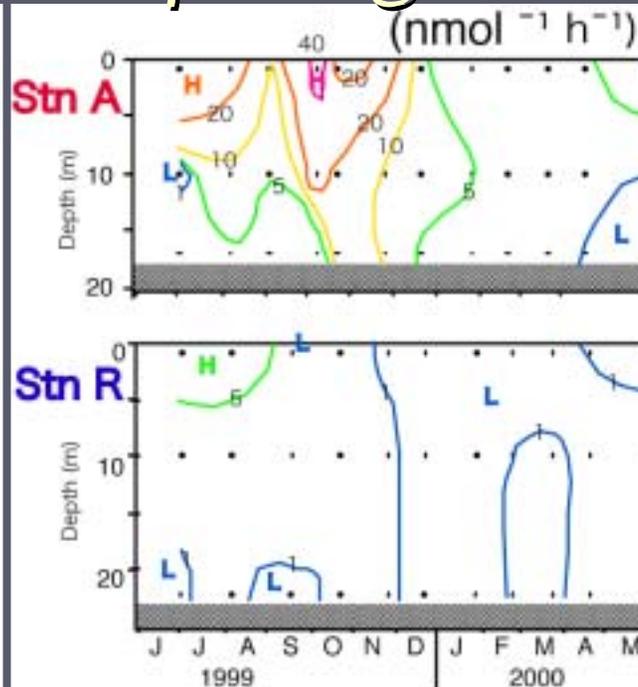
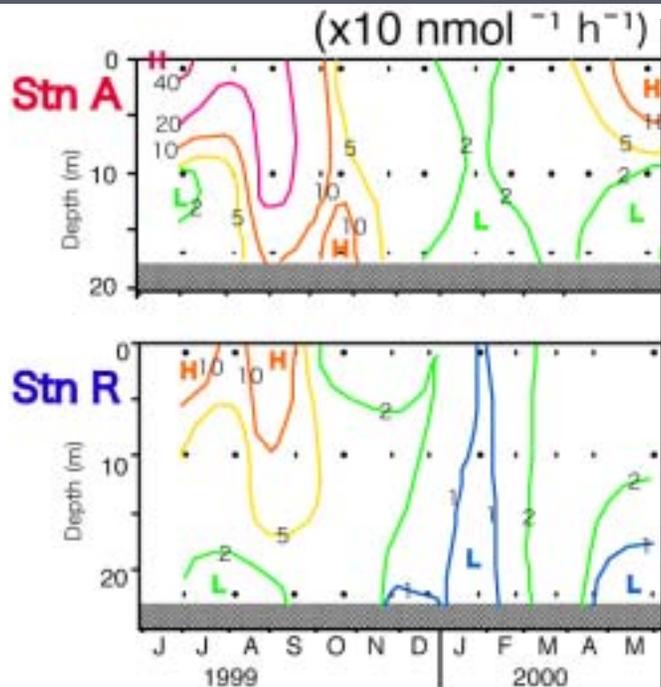
Hydrolytic enzyme activity in seawater

- ◆ β -D- glucosidase;
 β -linked polysaccharide degradation
- ◆ Leucine aminopeptidase;
Protein degradation

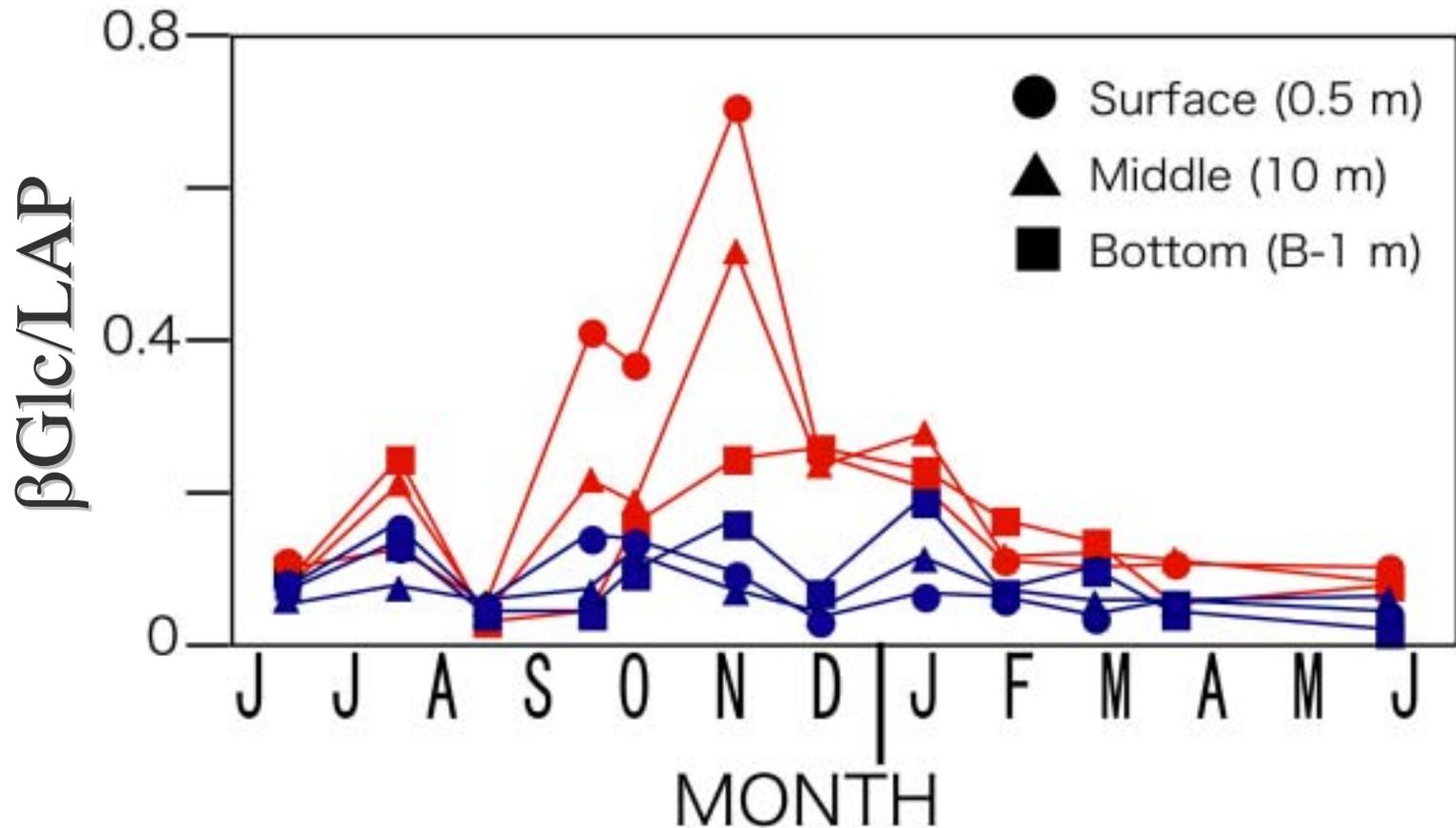
Microbial hydrolytic enzyme activity

Leucine aminopeptidase

β -D- glucosidase



Ratio of β -Glc to LAP activity



Aquaculture activity have stronger stimulatory effect on β -glucosidase activity than on leucine aminopeptidase activity

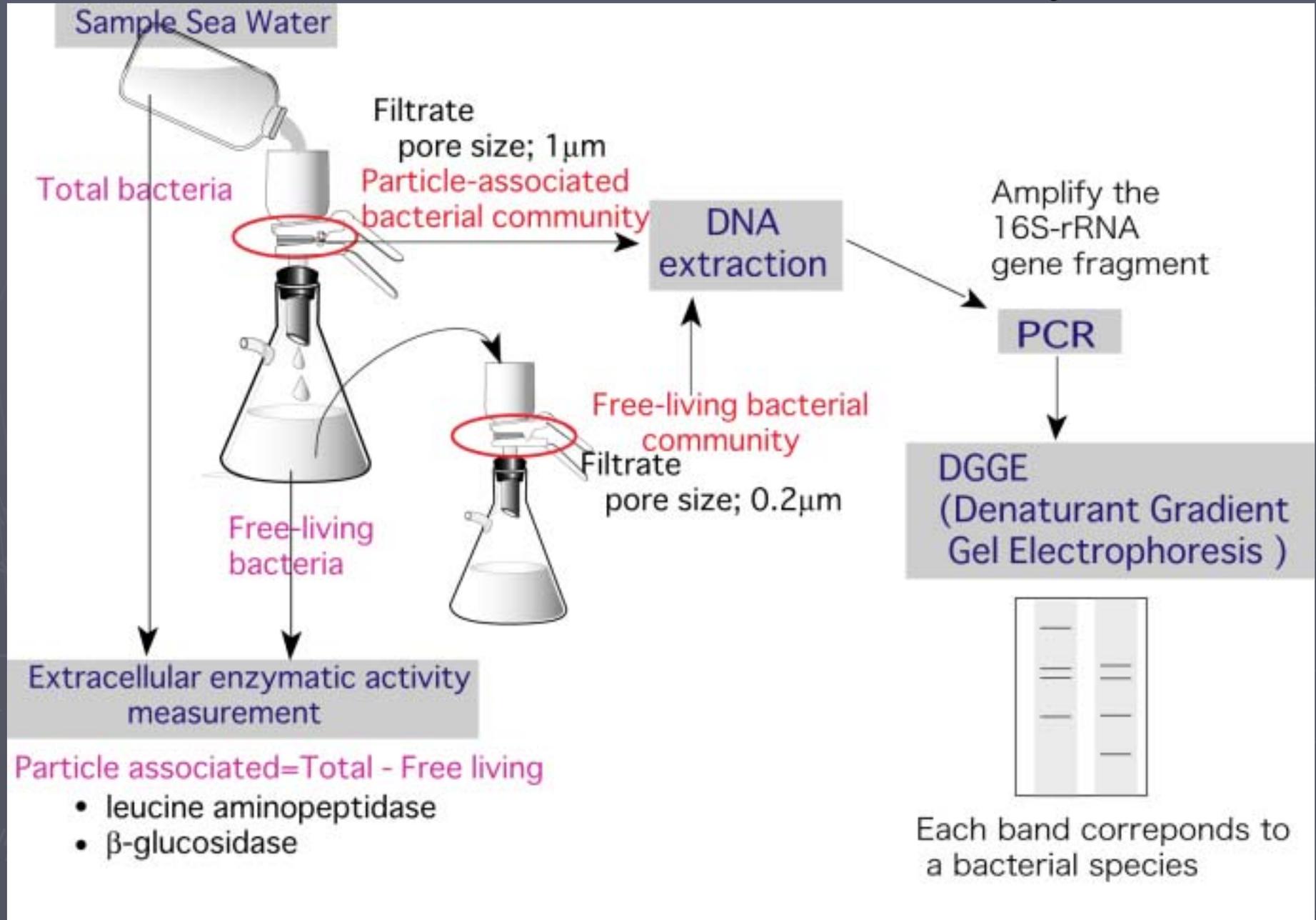
Correlation coefficients between bacterial and environmental parameters ($p < 0.05$)

Stn A	DOC	DON	POC	PON	Chla	Temp	Sal
LAP	0.49		0.87	0.86	0.83	0.57	-0.58
β -GLC	0.37		0.63	0.62	0.59		-0.54

Stn R	DOC	DON	POC	PON	Chla	Temp	Sal
LAP	0.39		0.66	0.67	0.64	0.54	-0.55
β -GLC	0.44		0.73	0.70	0.69	0.54	-0.53

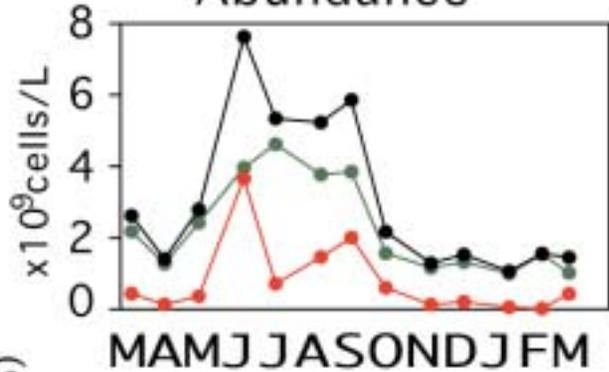
Particle associated bacterial community related to the high activity

How to examine the bacterial community structure

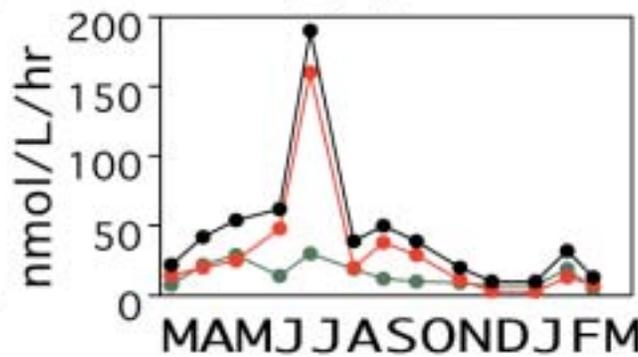


Total
 Particle-Associated
 Free-Living

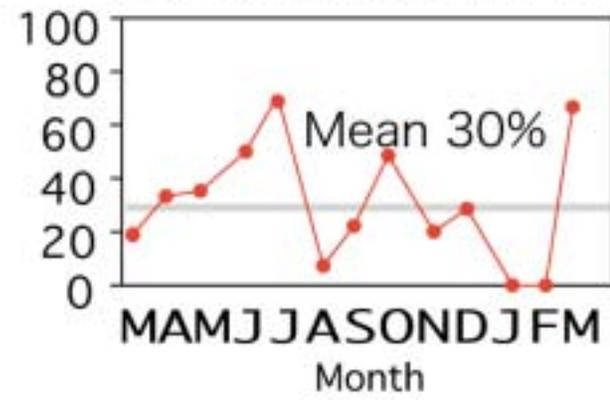
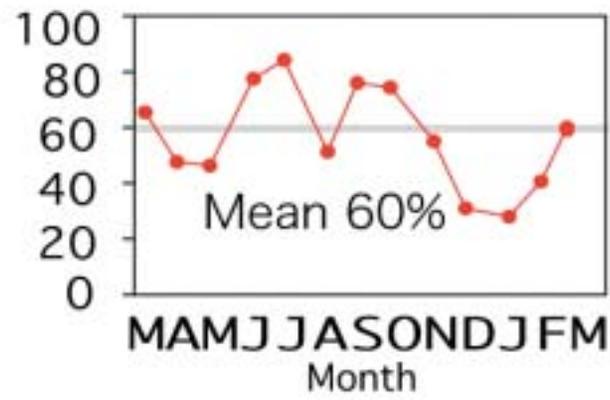
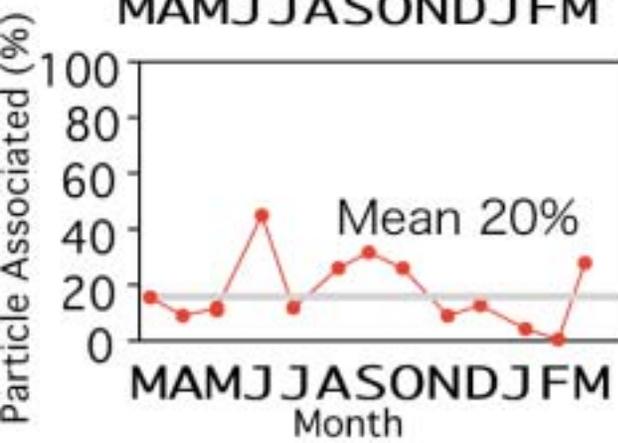
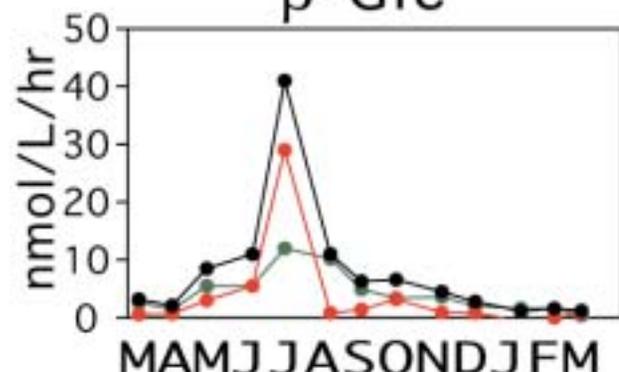
Bacterial Abundance



LAP



β -Glc

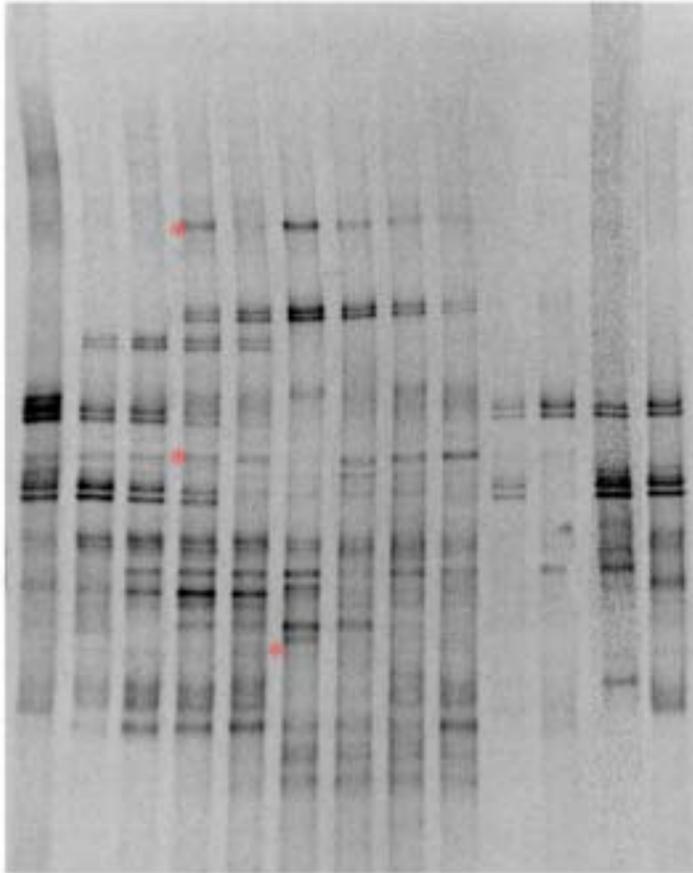


Free-living bacterial community structure

Aquaculture area

Month

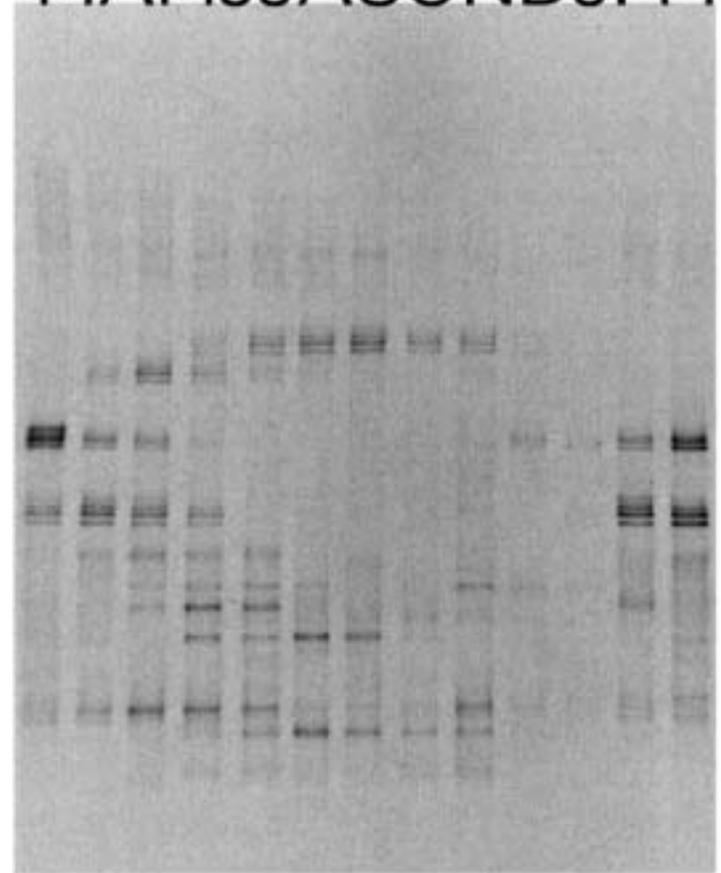
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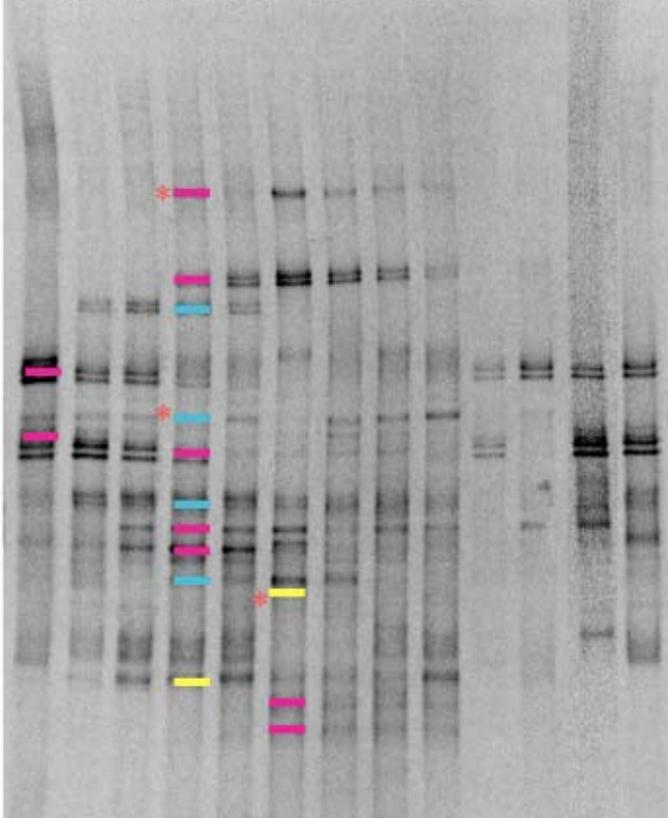
Reference area

Month

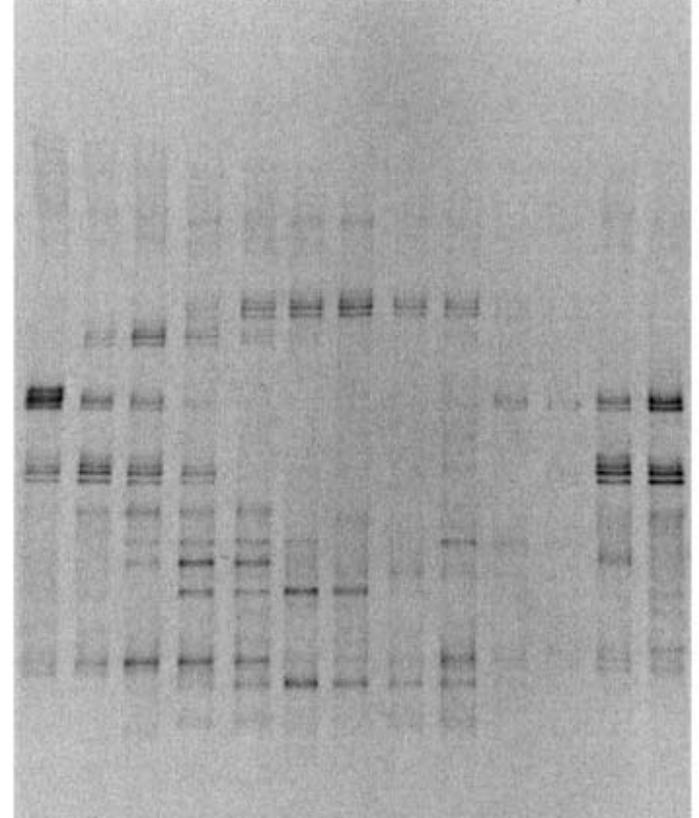
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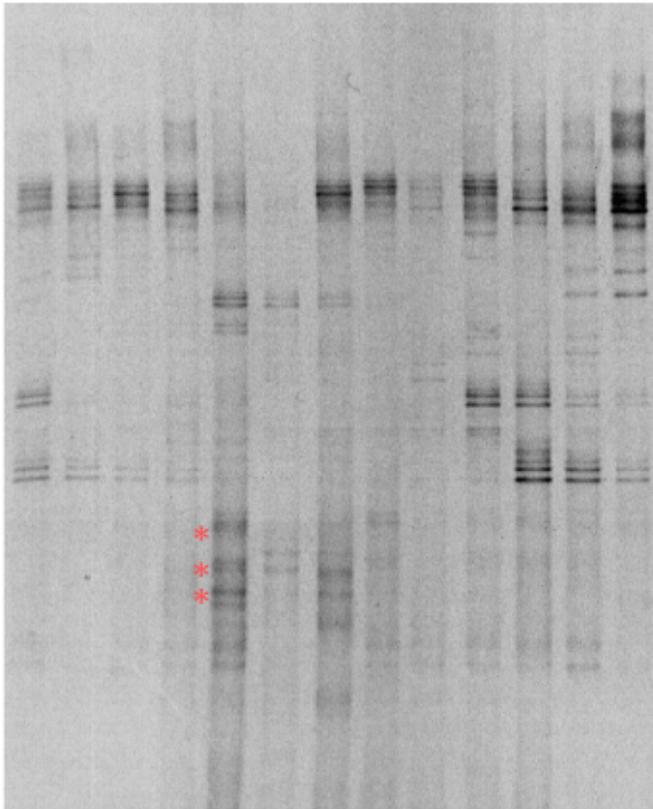


- Alpha subclass of the Proteobacteria
- Gamma subclass of the Proteobacteria

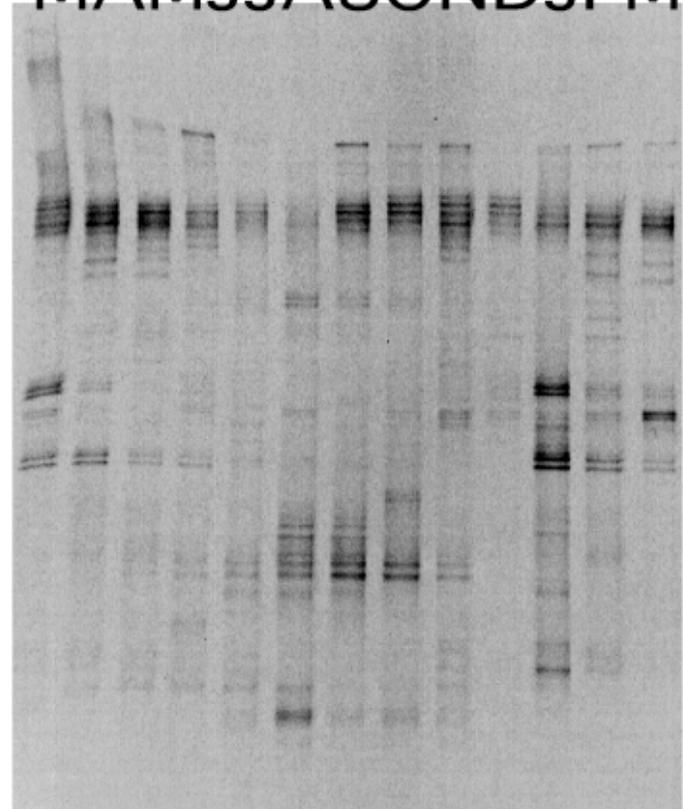
- Cytophaga-flavobacterium-bacteroides Group
- Cyanobacteria

Particle-associated bacterial community structure

Aquaculture area
Month
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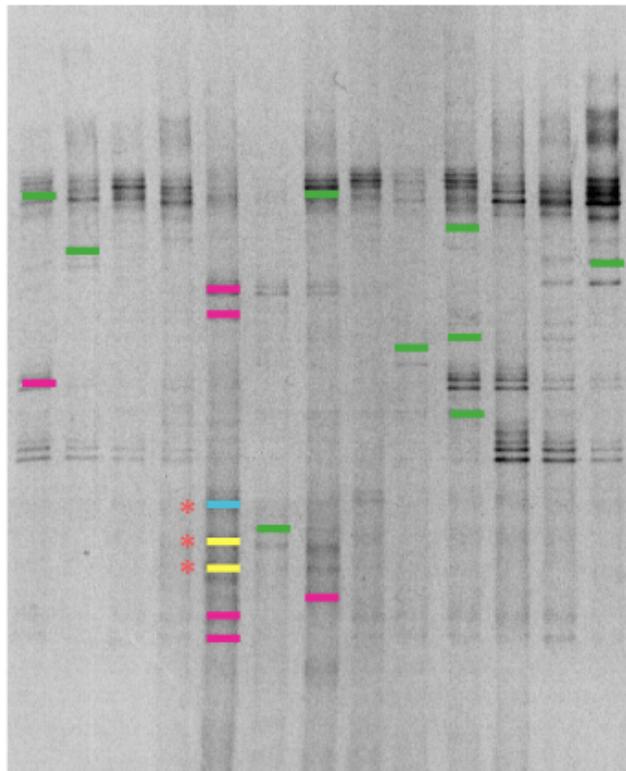
Reference area
Month
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Aquaculture area

Month

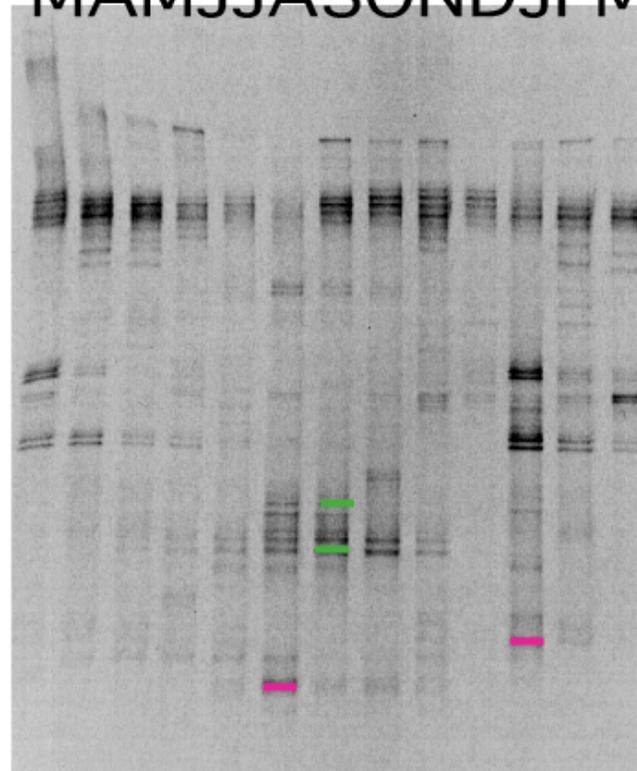
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Reference area

Month

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Alpha subclass of the Proteobacteria

Gamma subclass of the Proteobacteria



Cytophaga-flavobacterium-bacteroides Group

Cyanobacteria

High OM Degrading Ability

Production
Stn A / Stn R=
3

Closest identified
bacteria of specific
DGGE bands

β -Glc (Glycolytic)
activity
Stn A / Stn R=
5

Free-living
Community
80% of abundance
70% of β -Glc act.

- *Pseudomonas* sp.
(Apr ~ Nov)
- *Pelagibacter* sp.
(Jun ~ Oct)
- *Bacteroides* sp.
(Aug)

LAP (Proteolytic)
activity
Stn A / Stn R=
2
(Strong correlation
with POM)

Particle-associated
Community
20% of abundance
60% of LAP act.

- *Cytophaga* sp.
- *Bacteroides uniformis*
- *Pseudomonas stutzeri*
(Jul, Sep)

Summary

The microbial activities were promoted in the aquaculture area

- ◆ The stimulated bacterial secondary production was equivalent to the organic matter loads from fish farming
- ◆ Microbial poly-hydrocarbon degrading activity was promoted more than protein degrading activity.

The microbial community structure study has shown that

- ◆ Some specific bacterial species were observed at high activity season in the aquaculture area.
- ◆ Particle-associated bacterial community had high proteolytic activity, and some CFB-group bacteria probably related to the high activity in summer.